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MILITARY AIRLIFT

Status of C-17 Aircraft Development Program

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The Honorable Sam Nunn
Chairman, Committee on Armed Services
United States Senate

The Honorable Les Aspin
Chairman, Committee on Armed Services
House of Representatives

This briefing report provides information on the status of the development, production, and testing of the C-17 military transport aircraft that we presented to your staff on March 23, 1992. Conference Report 102-311, which accompanied the National Defense Authorization Act for fiscal year 1992 (Public Law 102-190), requires that we periodically report to the House and Senate Committees on Armed Services on the cost, schedule, and performance of the C-17 program.

Background

The C-17 military transport, being developed for the Air Force by McDonnell Douglas Corporation, Douglas Aircraft Company, is designed to airlift substantial payloads over long ranges without refueling. The Air Force originally planned to buy 210 C-17 aircraft. However, in April 1990, as a result of the Major Aircraft Review, the Secretary of Defense reduced the planned purchase to 120 production aircraft at an estimated cost of $35.8 billion.

The aircraft is being developed and produced under a fixed-price incentive contract[1] awarded in 1982. In addition to the test aircraft and two non-flying test airframes, the contract includes two options (lots I and II) for a total of six production aircraft. The ceiling price of the development contract, including both lots of production aircraft, is $6.637 billion. A separate fixed price contract for a third production lot of four aircraft was awarded on July 30, 1991, with a target price of $1.026 billion and a ceiling price of $1.215 billion. The C-17 program is presently in the

[1]A fixed-price incentive contract provides for adjusting profit and establishing the final contract price by applying a formula based on the relationship of total final negotiated cost to total target cost. Under this pricing arrangement, a target cost, target profit, price ceiling, and profit adjustment formula are negotiated. A final cost less than the target cost results in a final profit that is greater than the target profit. Conversely, a final cost more than the target cost results in a final profit that is lower than the target profit.

low-rate-initial-production phase. The full-rate-production decision is planned for March 1995.

Through fiscal year 1992, the Congress has appropriated $10.805 billion for the C-17 program, including (1) $5.266 billion for research, development, test and evaluation, (2) $5.425 billion for procurement, and (3) $114 million for military construction. The Air Force has awarded Douglas two contracts totaling about $7.663 billion for the development and production of the C-17, including one test aircraft and 10 production aircraft. Douglas and the Air Force are currently preparing to negotiate a contract for the fourth production lot of four aircraft using fiscal year 1992 procurement appropriations. For fiscal year 1993, the Air Force is requesting appropriations to purchase another eight production aircraft.

Results in Brief

C-17 program costs continue to grow. Costs incurred by Douglas on the development contract, including the six production aircraft, have exceeded the contract ceiling price of $6.637 billion and, on December 13, 1991, the government's estimate of the cost at completion was increased to $7.450 billion. In cost performance on that contract, Douglas reports spending $1.00 to accomplish $0.69 of planned work. That is, Douglas has a plan of work to be accomplished at a specific budget level. However, when actual costs are compared with budgeted costs, only $0.69 of planned work is being accomplished for every $1.00 spent.

Both aircraft delivery and testing schedules are experiencing problems. In July 1991, the Air Force modified the development contract to adjust the aircraft delivery schedule. Based on analyses of Douglas' production efforts, Air Force and Defense officials are projecting an additional slippage in the delivery schedule of up to 21 aircraft months. A slip of an aircraft month equates to one aircraft delivery slipping by 1 month. Flight testing of the C-17 is behind schedule due mainly to fuel leaks that grounded the test aircraft on three separate occasions, causing the loss of over 50 days of flight testing. Other problems have also surfaced that could affect future flight testing.

Douglas program data show that production efficiency is improving with each successive aircraft—meaning that Douglas takes fewer production hours to build each aircraft. However, the rate of improvement has not increased. A McDonnell Douglas production review team stated that improvement in the rate would be necessary for Douglas to meet its cost and schedule objectives.

Douglas claims that the level of quality on the C-17 program has improved because the dollar value of rework and repair has decreased on each successive aircraft. However, the cost of rework and repair per assembly hour of labor almost doubled between February 1991 and January 1992. Further, off-standard work hours, the major component of which is rework and repair, are increasing as a percentage of total hours. Off-standard hours accounted for about 40 percent of the work hours spent on each of the first two aircraft. Trends on subsequent aircraft show the percentage of off-standard hours increasing.

We agree that some quality improvements may be occurring, but we believe that Douglas has not taken into account the effect of the improved production efficiency on reducing rework and repair costs.

Appendix I provides additional details on these matters.

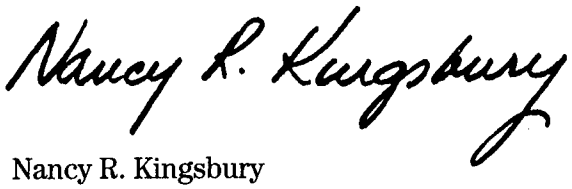
Scope and Methodology

We prepared this briefing report based on our ongoing work on (1) cost, schedule, and performance of the Douglas Aircraft Company's development and production of the C-17 aircraft and (2) initial developmental and operational testing and evaluation of the C-17 being conducted by the Air Force at Edwards Air Force Base, California.

We did not obtain written comments on this report. However, we did discuss these matters with Douglas and Air Force officials and incorporated their comments as appropriate. Our work was conducted between July 1991 and April 1992 in accordance with generally accepted government auditing standards.

Unless you publicly announce this report's contents earlier, no further distribution will be made until 30 days from its issue date. At that time, we will provide copies to the Secretaries of Defense and the Air Force; the Director of the Office of Management and Budget; and other interested congressional committees. Copies will also be made available to other interested parties upon request.

If you or your staff have questions on this briefing report, please call me on (202) 275-4268. Major contributors to this report are listed in appendix II.



Nancy R. Kingsbury
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Abbreviations

ACO	administrative contracting officer
CPI	cost performance index
DPRO	Defense Plant Representative Office
EAC	estimate of the cost at completion

Status of the C-17 Aircraft Development Program

The C-17 military transport aircraft is being designed to carry a full range of military cargo directly into small, austere airfields, including direct delivery to potentially hostile areas. The program began in 1982 when the Air Force awarded Douglas a fixed-price incentive contract for the full scale engineering development of the C-17 and the production of one test aircraft (T-1) and two non-flying test articles to be used for structural and durability testing. The development contract also includes two production options (lots I and II) for the manufacture of six production aircraft (P-1 through P-6).

In April 1990, as a result of the Major Aircraft Review, the Secretary of Defense reduced the program from the original target buy of 210 to 120 production aircraft. On July 30, 1991, the Air Force awarded Douglas another fixed-price incentive contract for a third production lot of four aircraft (P-7 through P-10). The Air Force plans to use fiscal year 1992 procurement appropriations to purchase four additional aircraft (lot IV) and is requesting fiscal year 1993 appropriations to purchase an additional eight aircraft (lot V). As of December 31, 1991, the Air Force estimated the C-17 program would cost $35.8 billion.

The C-17 program entered into the low-rate-initial-production phase in January 1989. The full-rate-production decision is currently planned for March 1995. Through fiscal year 1992, the Congress has appropriated $10.805 billion for the C-17 program. Some of these funds are used to cover government costs, such as management and testing, but the majority of the funds are for the contracts with Douglas Aircraft.

In 1991 we reported[1] that the C-17 program and Douglas continued to face significant schedule, cost, and performance challenges. Because of these difficulties, in April 1991, at the direction of McDonnell Douglas management, a team from McDonnell Douglas, independent of Douglas Aircraft Company, reviewed the program. The team assessed the status of the production effort and recommended 23 production improvements that would benefit the cost and schedule performance of the production process. These recommendations included increasing the emphasis on quality and reducing out-of-position work (work done out of its planned sequence or location). In our opinion, the degree of cost and schedule improvement that can be expected on the C-17 program is directly tied to the success Douglas achieves in implementing those recommendations.

[1]Defense Industry: Status of the C-17 Program and Related Issues Affecting the McDonnell Douglas Corporation (GAO/T-NSIAD-92-4, Nov. 14, 1991).

However, in March 1992, the Air Force C-17 program director told us that Douglas had been slow to implement these recommendations.

Contract Status

The development contract, including production lots I and II, is about 90 percent complete. The Air Force had obligated $6.226 billion against this contract as of December 29, 1991; about $5.788 billion of this amount had been approved for payment as of March 1992. The current ceiling price of this contract is $6.637 billion.

The production lot III contract is about 35 percent complete. The Air Force has obligated $1.026 billion against this contract of which about $303 million had been approved for payment as of March 1992. The lot III contract has a current target price of $1.026 billion and a ceiling price of $1.215 billion.

C-17 Program Costs Continue to Increase

The estimate of the cost at completion (EAC) for the development contract continues to increase. Costs incurred by Douglas have exceeded the contract ceiling price of $6.637 billion.

In November 1990, the C-17 administrative contracting officer reported that the Douglas EAC of $6.6 billion for the development contract was high risk and not likely to be achieved. In November 1990, the contracting officer adopted a government developed EAC of $7.1 billion for progress payment purposes. In July 1991, the contracting officer raised the EAC to $7.3 billion, and in December 1991, he raised it to $7.45 billion. An EAC that exceeds the ceiling on the contract results in a reduction in progress payments to reflect a portion of the expected loss—the higher the EAC, the greater the reduction.

As of March 1992, Douglas had spent about $6.724 billion, exceeding the $6.637 billion contract ceiling price, with about 10 percent of the work remaining. Further, Douglas had spent all but $10.2 million of the contract's $140 million management reserve available at the beginning of 1991. Thus, there is only $10.2 million remaining as a "cushion" for unexpected problems or cost growth. The contracting officer has reduced progress payments to Douglas reflecting the increased EAC and has only paid $5.788 billion in progress payments, as of March 1992.

The cost performance index (CPI) is an indicator of cost efficiency. The CPI measures contract cost efficiency by comparing work accomplished with

actual dollars spent for that work. Through January 1992, the cumulative CPI for the development contract stayed relatively stable at 0.69. This means that for every dollar spent on the development contract, 69 cents of planned work had actually been accomplished. However, since August 1991, the CPI for lot II production has gone down. Further, Douglas cost performance information shows that the cumulative CPI for flight testing of the C-17 test aircraft has dropped from 1.0 in April 1991 to 0.88 in November 1991.

In January 1992, the Defense Plant Representative Office (DPRO) analyzed cost trends for the development contract and concluded that attempts by Douglas to manage aircraft deliveries to achieve a schedule incorporating a 13-aircraft month slip from the contract schedule would result in further cost growth.

Aircraft Delivery and Testing Schedules Continue to Slip

The aircraft delivery schedule for the development contract continues to slip. We reported[2] that Douglas had missed major assembly and delivery milestones because of problems such as late engineering drawings and late delivery of tools. Problems in the development and testing of the aircraft avionics and Douglas' management of subcontractors also contributed to the schedule problems. In July 1991, when the lot III contract was awarded, a modification to the development contract slipped the aircraft delivery schedule again. In August 1991, Douglas and Air Force officials discussed revising the schedule again and agreed to manage the development contract deliveries to a new 13-aircraft month slip. According to program officials, this agreement recognized that the contract delivery schedule signed in July was not achievable.

By October 1991, based on additional monitoring of Douglas' production efforts, the C-17 program office and the DPRO began questioning whether even the 13-aircraft month slip schedule could be met. In November 1991, the program office developed an internal "what if" delivery schedule that showed a cumulative 21-aircraft month slip. In January 1992, based on further analysis and agreement from the DPRO, the program office concluded that the 13-aircraft month slip was probably not achievable and that a 21-aircraft month slip was more likely.

[2]Military Airlift: C-17 Faces Schedule, Cost, and Performance Challenges (GAO/NSIAD-89-195, Aug. 18, 1989).

Table I.1 provides a comparison of the contract delivery dates with the potential delivery dates. As of April 17, 1992, no production aircraft had been delivered.

Table I.1: Comparison of Aircraft Delivery Schedules

Aircraft	Contract schedule	13-month schedule	Months slipped	21-month schedule	Months slipped
Lot I					
P-1	2/92	3/92	1	4/92	2
P-2	12/91	5/92	5	6/92	6
Lot II					
P-3	3/92	7/92	4	8/92	5
P-4	7/92	9/92	2	10/92	3
P-5	10/92	11/92	1	12/92	2
P-6	12/92	12/92	0	2/93	2
Lot III					
P-7	2/93	2/93	0	3/93	1
Total aircraft months slipped			**13**	**1**	**21**

The flight test program began September 15, 1991, with first flight of the test aircraft to Edwards Air Force Base. The test program is a time phased, prioritized plan to be accomplished within an 80-aircraft month or 25-calendar month schedule. Table I.2 shows the status of specific test objectives planned and accomplished through March 15, 1992.

Table I.2: Test Objectives Planned and Accomplished, March 15, 1992

Objective	Planned	Accomplished	Percent accomplished
Total flights	65	45	69.2
Total flight hours	230	134.7	58.6
Credit flight hours	203	74.6	36.7
Flight test points	815	486	59.6
Maintenance test points	235	270	114.9
Remove and replace demo	109	105	96.3
Service equipment tests	25	18	72.0
Equipment compatibility	83	31	37.4

As the table shows, the test program is behind schedule in seven test objectives, including accomplishing only 36.7 percent of the credit flight hours (the estimated time to perform a specific test) and 59.6 percent of

the flight test points. According to Air Force test officials, the delays have been due primarily to a series of fuel leaks that grounded the test aircraft for weeks at a time, resulting in the loss of over 50 days of flight test and resulting in about 1 month slippage in the 80-aircraft month test schedule.

Other problems involve the flaps, leading edge slats, and nose gear retraction system. These problems, if not corrected in a timely manner, may further delay flight testing.

Production Efficiency Is Improving but Not Enough to Achieve Douglas' Goals

Douglas program data show that production efficiency is improving with each successive aircraft—it takes Douglas fewer production hours to build each aircraft. However, the rate of improvement has not increased.

The labor efficiency to build each aircraft is determined by the ratio of actual production hours to earned "standard" production hours (engineering estimates of the time required to perform various assembly tasks under ideal conditions). On the C-17 program, each aircraft's ratio is compared to subsequent aircraft and a learning curve is developed that shows the improvement in efficiency from aircraft to aircraft. In June 1991, the McDonnell Douglas production review team stated that the C-17 production learning curve would have to improve if Douglas' cost and schedule objectives were to be realized.

However, an improved learning curve has not been realized. In fact, current data suggest that while lot I production aircraft are at a stable efficiency level, lot II aircraft are showing a deterioration in their efficiency rates. According to the Douglas Vice President for Production, the first lot II aircraft, P-3, was the first aircraft to be affected by the production review team's recommendation to reduce out-of-position work. Douglas officials believe out-of-position work is a major cause of poor efficiency and quality. By doing more work in its planned position and sequence, efficiency in assembling the aircraft should improve. However, there has yet to be an improvement in the rate of efficiency for the overall P-3 assembly effort.

One way to improve production efficiency is by having industrial engineers analyze various work methods. However, Douglas decreased the C-17 industrial engineer work force from 209 in July 1990 to 69 in April 1991. As of February 1992, Douglas had increased this number to 102. According to Douglas officials, the fluctuations are due to a variety of reasons, including program funding instability and changes in Douglas' management.

Production Quality Trend Is Not Clear

Unlike production assembly efficiency, there is no agreed upon method for establishing quality trends on the C-17 program. Douglas tracks quality problems from aircraft to aircraft and programwide to determine the impact on program cost. Douglas program data show that actual rework and repair costs are decreasing for each successive aircraft. On the basis of the data, Douglas claims that the level of quality has improved.

We agree that some quality improvements may be occurring, but we believe that Douglas has not taken into account the effect of improved production efficiency on reducing rework and repair costs. The reduction in rework and repair costs may be a result of some quality improvement; however, it is also the result of improved production efficiency.

Other production trends suggest no improvement in quality. For instance, the cost of rework and repair per assembly labor hour has risen significantly over the last year. Based on a 12-month "moving average," rework and repair cost per labor hour nearly doubled, increasing from $4.38 in February 1991 to $8.49 in January 1992.

Further, "off-standard work" hours (work to correct non-conformance) as a percentage of total hours are increasing. At the time the first test aircraft flew in September 1991, approximately 40 percent of the total hours used to assemble the aircraft were attributed to off-standard work. By December of 1991, the next aircraft being assembled (P-1) also had a level of off-standard hours that was approximately 40 percent of the total hours to assemble the aircraft. All other aircraft currently being assembled show trends similar to the first two aircraft, with off-standard hours consuming an increasing proportion of the total assembly hours required.

Of all the off-standard work categories, the largest is repair. We examined work measurement data that showed that repair hours as a percent of the total assembly hours for the first four aircraft was constant, at about 22 percent. In other words, about the same percentage of time has been spent on repair of P-3 as was spent on repair of the test aircraft.

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